TOPIC 4: SUPPORT AND MOVEMENT IN PLANTS AND ANIMALS

1. **Support-** the ability of organisms to bear their weight and maintain their shape.
2. **Movement-** change of position of part or whole of an organism's body.
3. **Locomotion-** movement of the whole organism from place to place.

Examples of movement in plants.

i. Swimming of male gametes to the female gametes in bryophytes and pteridophytes.
ii. Growth of pollen tube down the style.
iii. Growth movements/tropisms.
iv. Nastisms/nastic movements.

Necessity/ Need for support and movement in plants.

1. Movement enables plants to adjust adequately to the environment.
2. Tropic and nastic movements enable plants obtain resources e.g. light, water and nutrients from the environment e.g. insectivorous plants.
3. Movement enables plants to escape/avoid harmful stimuli
   e.g. high temperature.
4. Support exposes fruits and seeds for dispersal and flowers for pollination.
5. Support helps the plants to resist breakage due to their own weight and weight of other organisms.
6. Growth of pollen tube in bryophytes and pteridophytes and swimming of male gametes bring about fertilization.
7. Support enables stems and branches to be held in position to allow leaves to be spread out to trap maximum light and for efficient gaseous exchange necessary for photosynthesis.

Ways through which plants compensate for their inability to move.

1. Plants show various responses to external stimuli such as nastisms and tropisms.
2. Green plants are autotrophic (make their own food) making them independent hence do not need to move in search of food.
3. Plants have parts that respond and grow extensively towards growth requirements such as water and light.
4. Plants have mechanisms for dispersal of seeds, spores and fruits.
5. Plants show various mechanisms of cross-pollination.

SUPPORT TISSUES IN PLANTS.

- They include; Parenchyma tissue, Collenchyma tissue, Sclerenchyma tissue and Xylem tissue (vessels and tracheids).

1. **Parenchyma tissue/cells.**

✓ Are large an unspecialized cells used for packing. They are spherical or elongated. Are found at the cortex and pith.
✓ The cells have large vacuoles that dissolve substances that increase osmotic pressure.
✓ The cells draw in water through osmosis becoming turgid/hard/ rigid hence providing mechanical support (e.g. in herbaceous plants).

2. **Collenchyma tissue.**

✓ Are elongated cells found beneath the epidermis of stem and leaf petiole.
✓ The collenchyma cell walls are thickened with **cellulose** making the cells rigid/ hard thus providing mechanical support.
✓ They are elongated.
✓ Its cells contain a living protoplasm and their walls are not lignified.
✓ It provides mechanical support in leaves, herbaceous plants and young woody plants.

3. **Sclerenchyma tissue.**

✓ It is found on the outside of phloem tissue/within the vascular bundle.
✓ It consists of dead cell walls thickened with **lignin** making it hard/rigid thus providing mechanical support.

4. **Xylem tissue (vessels and tracheids).**

✓ They perform the following functions:
a) Transport of water and mineral salts.
b) Mechanical support.
✓ Their cell walls tubular and are thickened with **lignin** to provide strength and mechanical support the plant.

Study questions.

(a) **What happens when a wilting young plant is well watered?**

✓ Root cells absorb water by osmosis, cells of the plant become turgid, and leaves become firm /spread out plant become firm / upright.

(b) **State three ways in which support is brought about in a leaf.**

✓ The rigid midrib holds leaf out away from the stem;
✓ Network of veins have lignified xylem which supports leaf enabling it spread out.
✓ Turgidity in spongy mesophyll/ palisade cells support the leaf to remain open.

SUPPORT IN STEM OF HERBACEOUS PLANTS

✓ Herbaceous plants lack vascular cambium hence do not have secondary thickening/growth.
✓ The cells are soft and are easily crushed and the plants are usually small and do not grow tall.

Ways through which herbaceous plants get mechanical support.

1. Their stems twine/ coil around support structures.
2. Use of hooks and tendrils which twist around other support objects.
3. Turgidity/ turgor pressure of parenchyma cells/ tissue.

- They have parenchyma tissue/ cells which draw in water through osmosis and become turgid thus providing mechanical support.
- During hot conditions the cells lose water/turgidity due to transpiration hence the plant wilts, bends and may collapse.

SUPPORT IN STEMS OF WOODY PLANTS.

- Stems of young woody stems contain parenchyma cells which absorb water through osmosis and they become turgid which makes the tissues firm and rigid providing mechanical support.

✓ The stems of mature woody plants contain **Collenchyma** cells are thickened with cellulose to give mechanical support.
✓ Have **sclerenchyma tissue** with ligni
✓ They also have **Xylem (vessels and tracheids)** with lignified walls to provide mechanical support.

Study questions.

2. **On a hot sunny day the shoot of herbaceous plant wilts and droops. Explain this observation.**

✓ The parenchyma cells lose water through osmosis and become flabby/ flaccid (hence cells lose turgor pressure).

3. **The shoot of a woody plant is less droopy of hot sunny day. Explain this observation.**

✓ The plant has support tissues that provide mechanical support.

4. **Some herbaceous stems have very little strengthening tissues yet still remain upright. Suggest how they are able to do this.**

✓ They have parenchyma tissues. When these tissues are turgid they provide mechanical support.

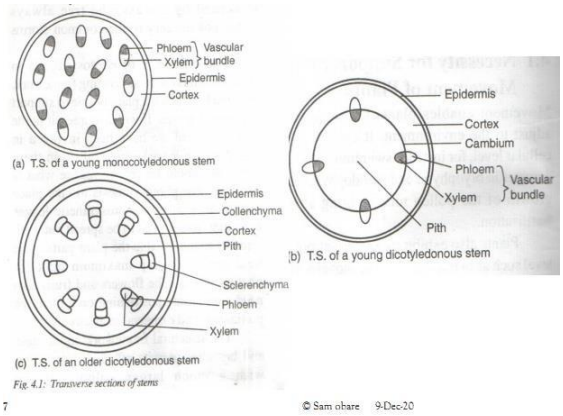

Fig. 4.1: Transverse sections of stems

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SUPPORT AND MOVEMENT IN ANIMALS.

Importance/ necessity of support and movement in animals.

1. Movement enables animals to look for food, shelter and mates.
2. Movement enables animals to escape from harmful stimuli/ unfavorable conditions.
3. Support holds the body organs in position.
4. Support helps to bear weight of the animal body.
5. Support gives the body its form and shape.
6. Support provides a surface for attachment of muscles to facilitate movement.

SKELETON.

- ✓ This is a supportive frame work in animal's body. The types of skeleton include:

A. Hydroskeleton/hydrostatic skeleton.
B. Exoskeleton.
C. Endoskeleton.

A. Hydrostatic skeleton- It is made up of supportive fluid under pressure surrounded by muscles.

- ✓ It is found in soft-bodied organisms e.g. earthworms.

B. **Exoskeleton-** It is found on the outside of the body of arthropods.

- ✓ The exoskeleton is made up of chitin. Chitin is secreted by the epidermal cells and when still soft it allows for growth of the insect.
- ✓ When chitin comes into contact with the air it hardens hence limiting growth.
- ✓ The exoskeleton limits growth hence to allow growth it is shed periodically in the process called **moulting/ ecdysis.**
- ✓ Chitin is not evenly distributed round the body but it is thin/flexible at joints to allow for movement.
- ✓ Chitin can be pigmented for camouflagation but it is transparent at the eyes to allow entry of light.

Functions of exoskeleton.

1. It is hard/ rigid to provide protection to internal body organs.
2. Provides support.
3. Provides a surface for muscle attachment to bring about movement.

Adaptation of the exoskeleton to its functions.

1. It hard to provide a surface for attachment of muscles which facilitates movement and protect internal organs against mechanical damage.
2. It is water proof preventing excessive water loss from body tissues through desiccation.
3. It is light and modified into wings / has low density for flight and can be modified to form hand jaws / mouthparts for biting/piercing /sucking / gliding.
4. It is pigmented/ colored for camouflagation.
5. It can be transparent at some places allowing entry of light into the eyes and for camouflagation in water.

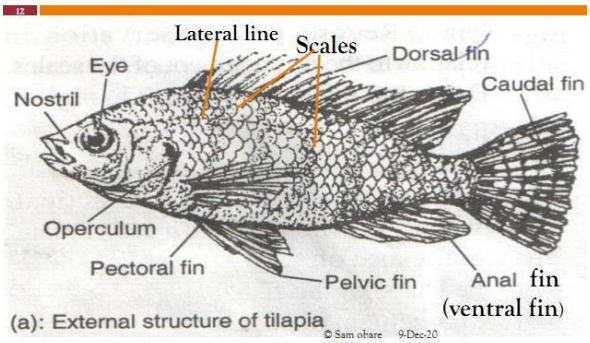
C. **Endoskeleton.**

- ✓ It is found inside the body of vertebrates and surrounded by muscles.
- ✓ Endoskeleton is made up of living tissues (i.e. bones and cartilage).
- ✓ These living cells grow within the animal and do not limit growth.
- ✓ **A bone** is a rigid structure made up of living cells, and inorganic compounds.
- ✓ **A cartilage** is a flexible connective tissue.

Functions of endoskeleton/ bones.

1. It protects internal delicate organs (e.g. heart, lungs and brain) from mechanical injury.
2. It supports the body weight and gives the body its shape.
3. It provides a surface for attachment of muscles which contract and relax to bring about movement.
4. Bone marrows produce the blood cells.
5. Bones act as a reservoir of calcium and phosphate ions in the body which cause hardening of the bone tissue.

LOCOMOTION IN FINNED FISH e.g. Tilapia.



MECHANISM OF LOCOMOTION/ HOW LOCOMOTION OCCURS IN FINNED FISH/ ADAPTATION OF FISH TO LOCOMOTION IN ITS HABITAT/ WATER e.g. Tilapia.

1. It has **streamlined body** to reduce resistance to enable it move easily through water.
2. It has **inflexible head** which enables fish to maintain forward thrust.
3. It has s**cales** that overlap and point backwards to reduce friction/ resistance during movement.

- ✓ Overlapping of scales prevent wetting of the skin.

4. It **secretes mucus** which covers the body and reduces friction during movement.
5. It has **flexible backbone** with muscle blocks (called **myotomes**) which contract and relax to bring about side to side (undulating) movement.

- ✓ The side to side movement creates forward thrust and propels the fish forward.

6. It has **lateral line system** along the length of the body for sensitivity (i.e. enable it detect vibrations and changes of pressure in water) enabling it to respond suitably.
7. It has **a swim bladder** (between the vertebral column and the gut) which provides it with buoyancy and enable it to adjust its vertical position.

- ✓ When the swim bladder is filled with air the body density is lowered hence it occupies a higher level in water.
- ✓ When air is expelled from the swim bladder, the density of fish increases hence fish sinks to lower level.

8. It has **paired fins (pectoral and pelvic fins)** for maintaining balance, braking, changing direction and preventing pitching (i.e. upward and downward movement of fish) during movement.

- ✓ When changing position, the paired fins act as pivots around which the fish turns rapidly.
- ✓ When braking, maintaining balance and preventing pitching, the paired fins extend rapidly outwardly at right angles to the body.

9. It has **unpaired fins (dorsal, anal and caudal fins)** to prevent **rolling** (rocking from side to side), prevent **yawing** (lateral deflection of the body.

- ✓ The caudal fin propels the fish forward and steers the fish while in motion.

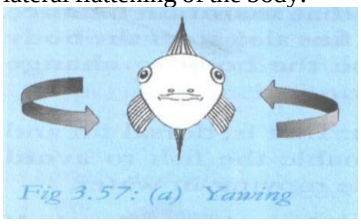
10. It has lateral flattened body shape to increase vertical surface area of the body.

✓ This prevents yawing, rolling and keeps the fish in upright position.

Displacements experienced by fish during movement.

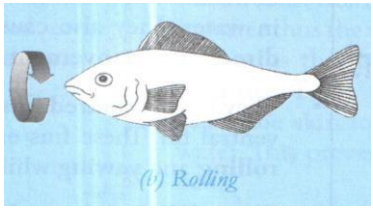
1. **Yawing**: This is the lateral deflection of the body.

✓ It is counteracted by dorsal, ventral/anal fins and the lateral flattening of the body.



2. **Rolling**: This is rotation of the fish around its own axis.

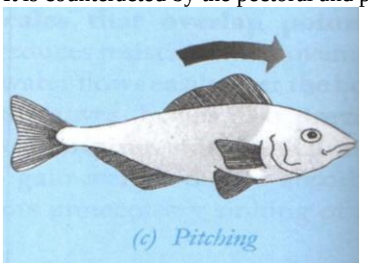
✓ It is counteracted by dorsal and anal/ ventral fins which increase the vertical surface area of the body.



✓

3. **Pitching**: This is plunging into the water headfirst (nosediving).

✓ It is counteracted by the pectoral and pelvic fins.



Tail power.

✓ This is the percentage ratio of length between the tail tip and anus and the length between the tail tip and the mouth tip.

Tail power= **length of the tail tip to anus x** 100

Length from tail tip to mouth

Importance/ significance of high tail power.

✓ It enables fish to create a high forward thrust that propels the fish forward.

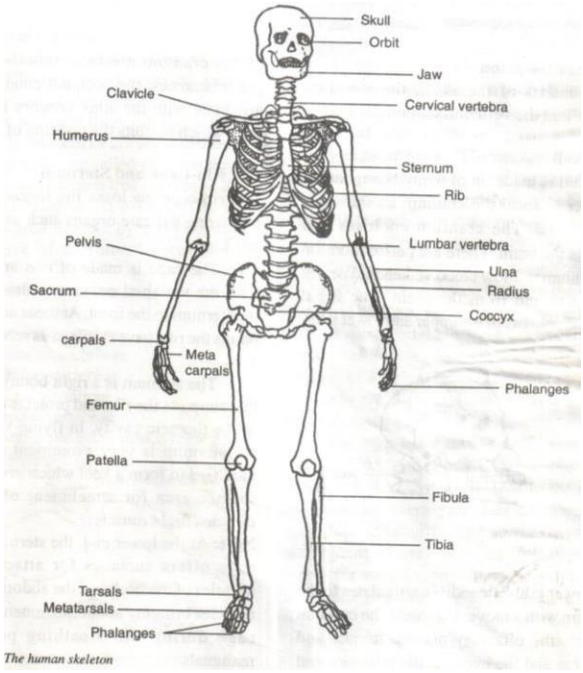
SUPPORT AND MOVEMENT IN MAMMALS e.g. man

Parts of mammalian skeleton

A. Axial skeleton.
B. Appendicular skeleton.

A. Axial skeleton- It is made up of the following parts:

1. Skull.
2. Rib cage.
3. Vertebral column.



The human skeleton

1. **The Skull.**

✓ It consists of the **cranium, upper jaw (maxilla) and lower jaw (mandible).**

✓ The cranium is the part of the skull which protects the brain, olfactory organs, middle and inner ear and the eyes.

✓ The skull is made up of flattened bones (cranial and facial bones) joined/articulated to form immovable/ fixed joints called **sutures.**

✓ Sutures allow passage of blood vessels and nerves to and from the brain**.**

Adaptation of sutures.

i. The bones interlock/ fit into each other forming strong joints to protect the brain.

ii. They are immovable/ fixed/ tightly holding for protection of the brain.

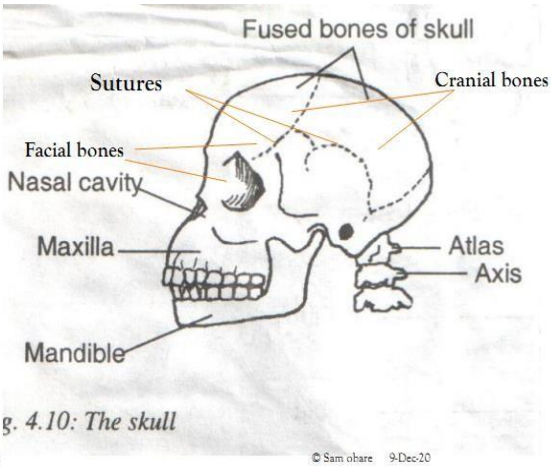
✓ The cranium and the upper jaw are fused but the lower jaw articulates with the cranium to form a movable joint.

✓ There is a large opening at the base of the cranium called **foramen magnum** for the passage of the spinal cord.

✓ There are two rounded projections on either side of the foramen magnum called **occipital condyles** with smooth surfaces to articulate with the first neck bone (**atlas)** to form a joint to allow nodding of the head.

Functions of the skull.

1. It protects the brain, inner parts of the ears, nose and eyes from mechanical damage.
2. Offers a surface for the attachment of the head muscles.
3. Provides mechanism for chewing.
4. Articulates with cervical vertebrae to allow movement of the head.



g. 4.10: The skull

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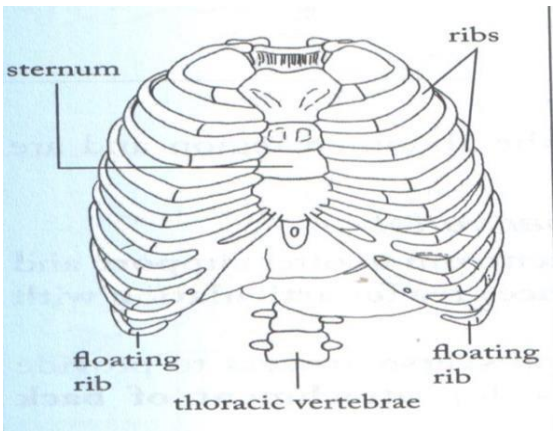
2. **THE RIB CAGE.**

✓ The rib cage encloses the thoracic cavity protecting delicate organs e.g. heart and lungs.
✓ It consists of 12 pairs of ribs articulating with **thoracic vertebrae** at the **back/dorsal** end and the sternum to the **front/ventral end** by a **cartilage.**
✓ The last two ribs are not attached to the sternum hence called **floating ribs.**
✓ The **sternum/breastbone** is made up of small fused bones called **sternbrae** found at the ventral side of the chest.
✓ It supports the ribs and protects the organs in the thoracic cavity.
✓ In flying vertebrates it is modified to form a keel which gives a large surface area for attachment of pectoral/ flight muscles.

Functions of rib cage.

1. Encloses the thoracic cavity and protects the delicate body organs e.g. heart, lungs from mechanical damage.
2. Provides a site for attachment of intercostal muscles hence brings about breathing.
3. Floating ribs offer a site for attachment of back muscles.



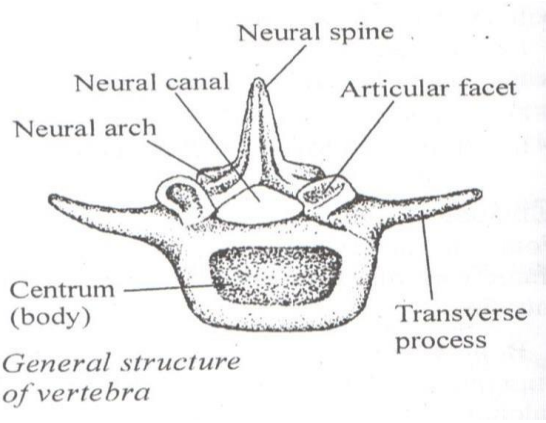
3. **VERTEBRAL COLUMN/ BACKBONE.**

✓ It protects the spinal cord.
✓ It is made up of small bones called **vertebrae (singular- vertebra).** In man there are 33 vertebrae separated from each other by cartilages called **inter-vertebral discs.**

Functions of intervertebral discs.

1. They act as a cushion that absorbs shock and reduces friction.
2. They make the vertebral column flexible by allowing for certain degree of movement between the vertebrae.

STRUCTURE/ PARTS OF A VERTEBRA.



General structure of vertebra

1. **Centrum-** this is the solid structure of the vertebra which supports the weight of adjacent vertebra.
2. **Transverse processes / projections-** they are two and project laterally and provide a site for muscle and ligament attachment.
3. **Neural/spinal canal-** it allows for the passage and protection of the spinal cord.
4. **Neural spine-** it projects dorsally and provides a site for attachment of muscles.
5. **Neural arch-** it is a curved part which arises from the centrum and surround the neural canal.

- **Together with the centrum they protect the spinal cord.**

6. **Articulating facets/surfaces-** are used for- articulation with the adjacent vertebrae).

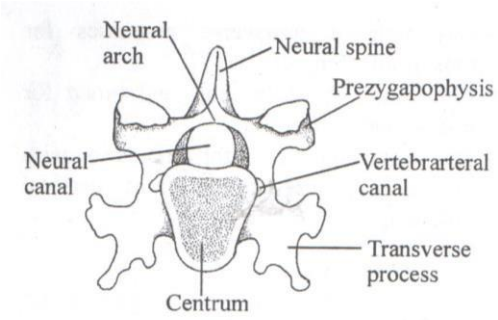
- Those found on the anterior end are called **pre-zygapophyses.** They face upwards and inwards.
- Those that are found at the posterior end are called **post-zygapophyses.** They face downwards and outwards.
-

TYPES OF VERTEBRAE

✓ They include:
A. Cervical/neck vertebrae.
B. Thoracic vertebrae.
C. Lumbar vertebrae.
D. Sacral vertebrae.
E. Caudal/coccygeal vertebrae.

A. **CERVICAL VERTEBRAE.**

✓ They 7 in number and are found at **the neck region** the first cervical vertebra is called **atlas,** the second is **axis** and the remaining five are called **cervical vertebrae.**



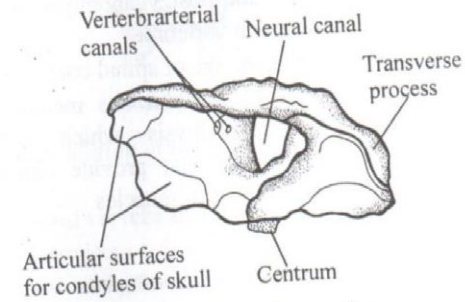
Anterior view of ordinary cervical vertebra of sheep

General adaptations of cervical vertebra.

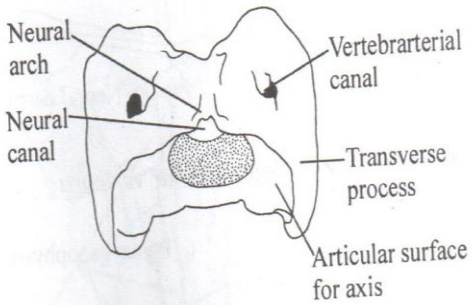
1. It has **vertebraterial canals** which provide a passage for the vertebral artery and nerves.
2. It has **branched and broad transverse processes** to increase the surface area for attachment of muscles.
3. It has centrum and neural arch for protection of spinal cord
4. It has **short/reduced neural spine** for the attachment of the neck muscles.
5. It has **a wide/large neural canal** for the passage of the spinal cord.
6. It has **post- zygapophyses and pre-zygapophyses** to articulate with adjacent vertebrae.
7. It has **large and thick centrum** to provide support to the adjacent vertebrae.

THE ATLAS.

✓ This is the first cervical/ neck bone.

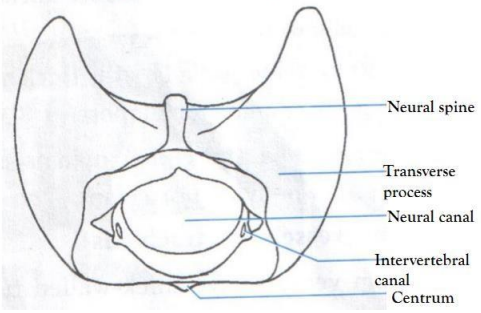


Anterior-lateral view of sheep atlas



Dorsal-posterior view of sheep atlas

Ventral-posterior view of atlas.

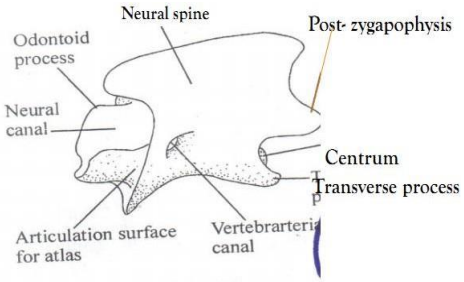


Adaptations.

1. It has **broad (inward curved anterior) surfaces or facets** for articulation with the occipital condyles of the skull forming a joint which allows nodding of the head (up and down movement of the head).
2. It has **broad and wing-like** transverse processes to provide large surface area for attachment of the neck muscles.
3. It has a **large/wide neural canal** for the passage of the spinal cord and to accommodate the **odontoid process** of the **axis** to allow movement of the head.
4. It has **vertebraterial canals** for the passage of the vertebral artery and nerves.

THE AXIS

✓ This is the second cervical bone.



Lateral view of atlas of sheep

Adaptations.

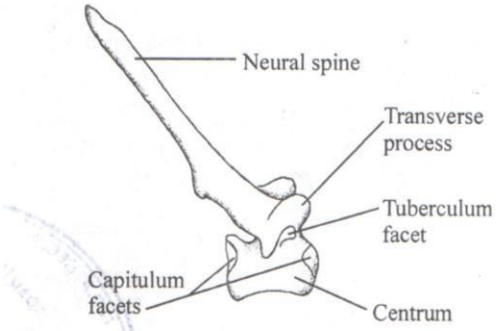
1. It has a short and wide/broad neural spine that projects forward to increase surface area for muscle attachment.
2. The **centrum** projects to the anterior end to form the **odontoid process** which forms a peg that fits into the neural canal of the atlas forming a joint.

✓ The joint formed allows turning/sideways/ rotary movement of the head.

3. It has **reduced/short transverse processes** for muscle attachment.
4. It has post zygapophyses for articulation with adjacent cervical vertebra and also a facet (on the anterior end) to articulate with the **atlas.**
5. It has vertebraterial canals for the passage of the vertebral artery and nerves.

B. **THORACIC VERTEBRAE**.

- ✓ They are 12 in number and found at the chest/thoracic region of the vertebral column.
- ✓ They articulate with the ribs forming rib cage.
- ✓ The first thoracic vertebra articulates with the last cervical vertebra.



Lateral view of sheep thoracic vertebra

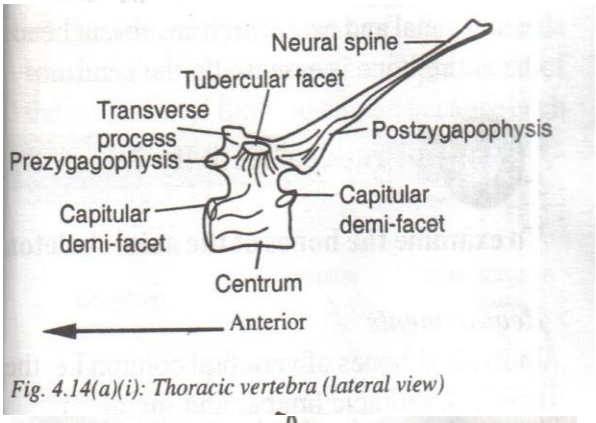


Fig. 4.14(a)(i): Thoracic vertebra (lateral view)

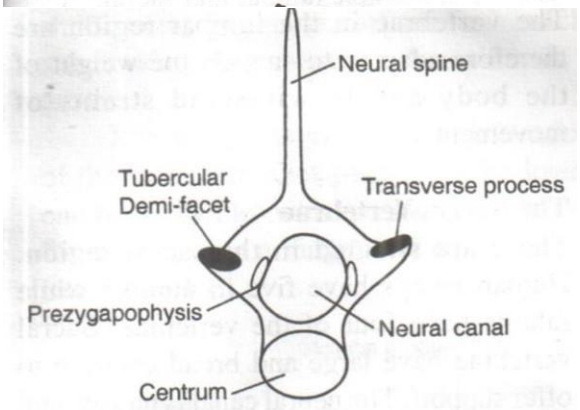
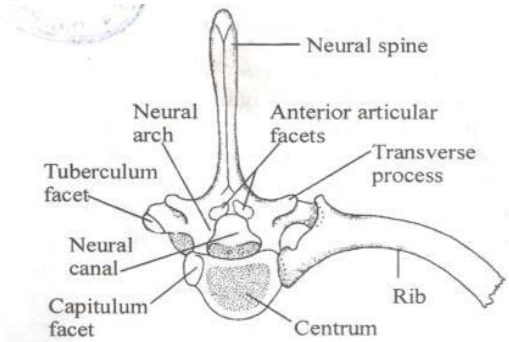


Fig. 4.14(a)(ii): Thoracic vertebra (anterior view)



Anterior view of sheep thoracic vertebra showing articulation with rib

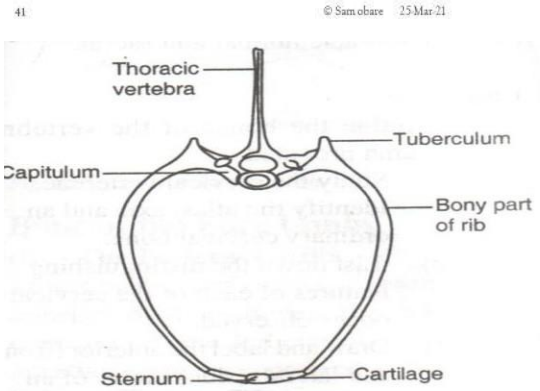


Fig. 4.14(b)(i): Ribs and their attachments

Adaptations of thoracic vertebra.

1. It has **long neural spine** (which points towards the posterior) to offer large or increase the surface are for attachment of the thoracic/back muscles.
2. It has short/ reduced **transverse processes** for attachment of muscles.
3. It has **neural canal** for passage of spinal cord.
4. The **transverse processes** have articular facets called **tubercular facets** to articulate with the **tuberculum** of the rib.
5. The **centrum** has articular facets called **capitular facets** to articulate with the **capitulum** of the rib.
6. It has **large/ thick centrum** to support the other vertebra/body weight.
7. It has anterior facets **(pre-zygapophyses)** and posterior facets **(post-zygapophyses)** to articulate with the adjacent thoracic vertebrae.
8. They have centrum and neural arch to protect spinal cord.

MAMMALIAN RIB

- ✓ It is located on the ventral end of rib cage or on thoracic region.
- ✓ It articulates with thoracic vertebrae at capitular and tubercular facets.

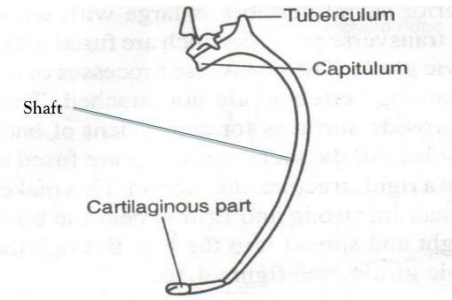


Fig. 4.14(b)(ii): Mammalian rib

Adaptations of the mammalian rib.

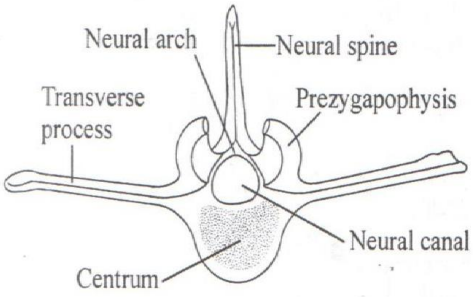
i) It has **long shaft** to provide a large surface area for attachment of muscles.

ii) It has **tuberculum** to articulate with tubercular facet of the transverse process of the thoracic vertebra.

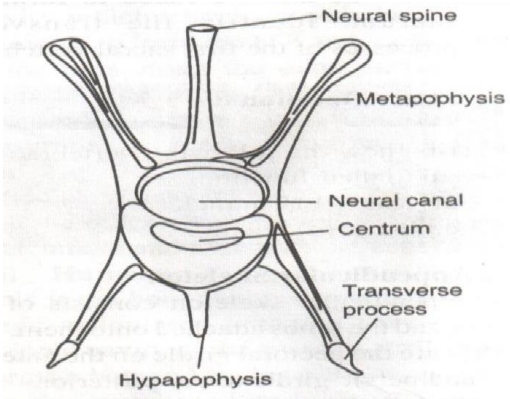
iii) It has **capitulum** to articulate with capitular facet of the centrum of the thoracic vertebra.

C. **LUMBAR VERTEBRAE.**

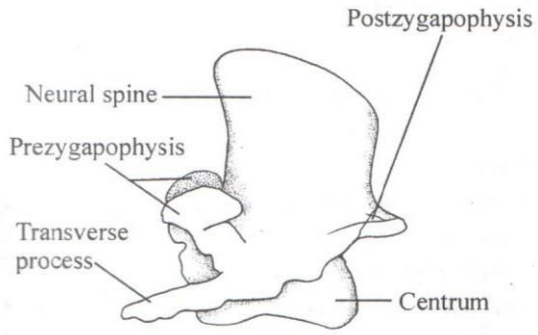
- ✓ They are 5 in number located in the abdominal/lumbar region of the body.
- ✓ The first lumbar vertebra articulates with the last thoracic vertebra.



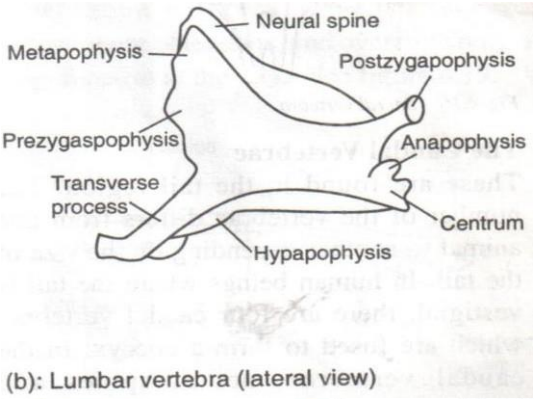
Anterior view of sheep lumbar vertebra

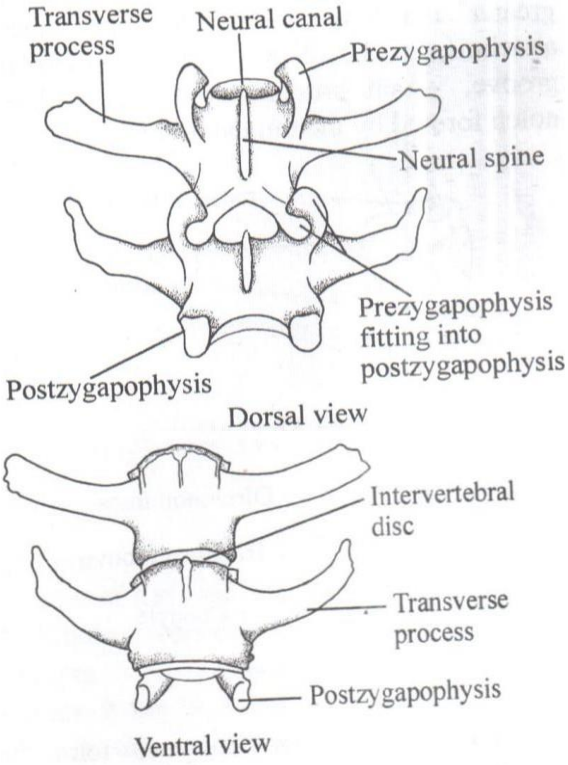


4.15: The lumbar vertebra



Lateral view of sheep lumbar vertebra





Articulation of two lumbar vertebrae

Adaptations of lumbar vertebra.

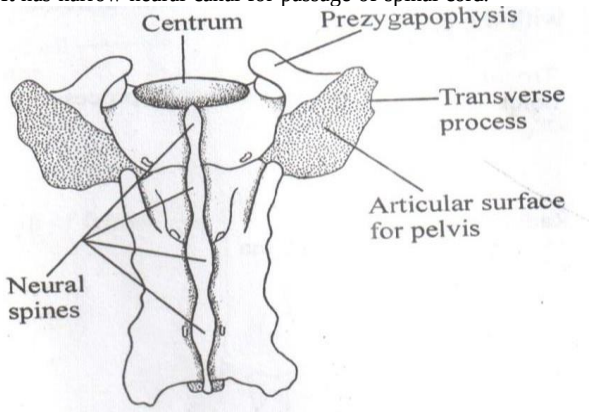
1. It has **broad neural spine** to provide a large surface area for attachment of powerful back and abdominal muscles.
2. It has **long transverse processes** to increase the surface area for attachment of powerful back muscles.
3. It has **neural canal** for passage of spinal cord.
4. They have centrum and neural arch to protect spinal cord.

5. It has a **large and broad centrum** to support the weight of the adjacent vertebra.
6. It has **two metapophyses** (on either side of the neural spine), **anapophyses** (projecting dorsaly near the transverse process) and **hypapophysis** (ventrally to the centrum) to offer large surface area for attachment of abdominal muscles.
7. It has curved post- zygapophyses and pre-zygapophyses for articulation with adjacent vertebrae and for muscle attachment.

D. **SACRAL VERTEBRAE (SACRUM).**

Adaptations of sacral vertebra

1. It consists of 4 of 5 vertebrae **that are fused to make it strong** and firm to bear the weight of body and spread it to the legs through pelvic girdle.
2. The first 2 sacral vertebrae (anterior vertebrae) are **large with wing-like transverse processes** which are fused to the pelvic girdle to provide a surface area for attachment of the pelvic and back muscles.
3. The sacrum **has a large base or short neural spine** for attachment of back muscles.
4. It has **large and broad centrum** to provide support.
5. There are openings called **intervertebral foramen** which allow the passage of the spinal nerves.
6. It has pre-zygapophyses that articulate with the lumbar vertebra.
7. It has narrow neural canal for passage of spinal cord.



Dorsal view of sheep sacrum

E. **CAUDAL/ TAIL/ COCCYGEAL VERTEBRAE.**

✓ They are found on tail region. They are 4 in number fused to form a bone called **coccyx.**
✓ The neural spines and zygapophyses are reduced.
✓ The neural canal and neural arch are absent hence the entire bone is a centrum.

2. **APPENDICULAR SKELETON.**

✓ It consists of:
a) Girdles.
b) Limbs (attached onto girdles)

a) **Limb girdles.**

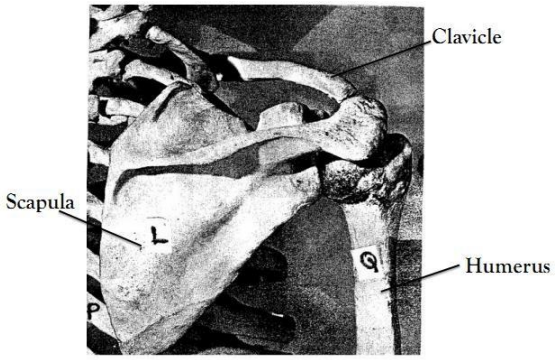
▪ They hold the limbs in position and include:
1. Pectoral girdle (on the anterior end).
2. Pelvic girdle (on the posterior end).

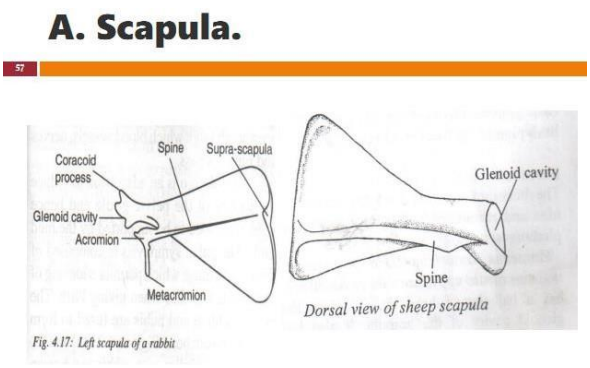
Functions of girdles.

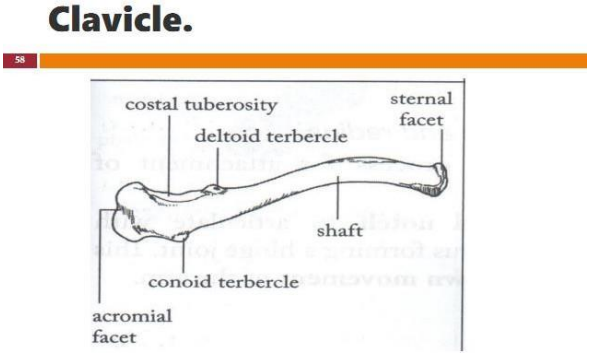
i. Form a connection between the axial skeleton and limbs.
ii. Provide suitable surfaces for attachment of muscles that move the limbs.
iii. They keep the limbs apart for stability.

1. **Pectoral girdle.**

✓ It is found at the shoulder region and made up of two halves i.e. right and left side.
✓ It links the fore limbs to the axial skeleton and forms the joints with the fore limbs to allow movement.
✓ It has two types of bones i.e. Scapula and Clavicle.
✓ The **clavicle** articulates with the **sternum** and the **acromion** of the **scapula.**







Adaptations of pectoral girdle.

a) **The scapula**

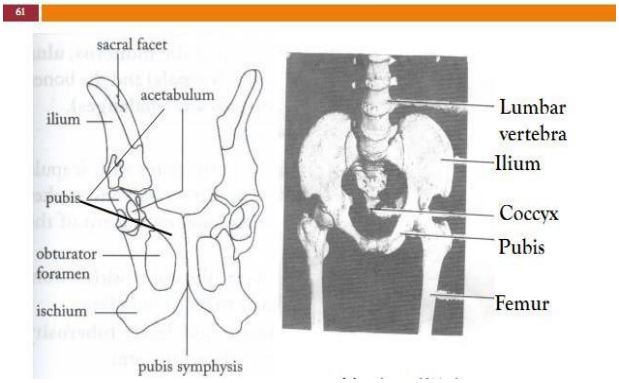
1. It has a **glenoid cavity/ socket/depression** which articulates with the head of the humerus to form a ball and socket joint to allow movement of the arm in all directions.
2. Has broad/flat blade to increase the surface area for attachment of muscles.

3. Has long spine to increase the surface area for attachment of muscles.
4. It is hard/ rigid to provide support.
5. Has a ridge or coracoid process to increase surface area for muscle attachment.
6. It has a cartilage (suprascapula) at the edge of the blade to reduce friction.
7. It has **acromion for** articulation with the clavicle and muscle attachment and **metacromion** for attachment of shoulder and back muscles.

b) **Clavicle.**

1. It has **long shaft to provide large surface area for** attachment of chest muscles and also helps in movement of the arm.
2. It has acromial facet for articulation with acromion (of scapula) and sternal facet for articulation with sternum.
3. It is hard and calcified to ensure firmness hence providing support and for attachment of muscles.

2. Pelvic girdle.



- ✓ The pelvic girdle is found at the hip/pelvic region consists of two halves of fused bones
- ✓ The two halves are joined at the **pubis symphysis** which consists of a cartilage.
- ✓ In female it is flexible to allow widening of the pelvic girdle during giving birth.

Functions of pelvic girdle.

1. Forms joints with the legs to make walking possible.
2. Provides a large surface area for attachment of muscles.
3. Offers support to the body weight.

- ✓ Each half of the pelvic girdle consists of 3 fused bones namely:

1. **Ilium-** long and upward pointing/ above the **aceabulum** to provide a large surface area for attachment of thigh muscles.
   - ✓ It also **has a wide facet for articulation** with the sacrum.
2. **Ischium-** bone on the dorsal end that supports the body on sitting position.
3. **Pubis (pubic bone) -** is found on the inside/ventral side of the ischium.

- ✓ The pubis (pubic bone) has a socket called **acetabulum** which articulates with the head of femur forming a ball and socket joint (that allow movement in all planes).
- ✓ Between the **pubis** and **ischium** there is a hole next to the socket called **obturator foramen** for the passage of blood vessels, nerves and muscles.

Adaptations of the pelvic girdle.

1. It has **acetabulum** to articulate with the head of femur to form ball and socket joint allowing movement of the hind limb.
2. It is made up of three bones which are fused together to form a rigid structure to provide support.
3. It has **broad ilium** to provide a large surface area for attachment of thigh muscles.
4. The ilium has a broad facets for articulation with the transverse processes of the sacrum.
5. It has **obturator foramen** for the passage of blood vessels, nerves and muscles.
6. It has **pubis symphysis** composed of flexible cartilage which allows widening of the females' pelvic girdle when giving birth and acts as a shock absorber.

B. **THE LIMBS.**

- ✓ There are two types of limbs that occur in pairs and include:

1. Fore limbs (found at the anterior end of the body and connected to pectoral girdle).
2. Hind limbs (found at the posterior end of the body and connected to pelvic girdle).

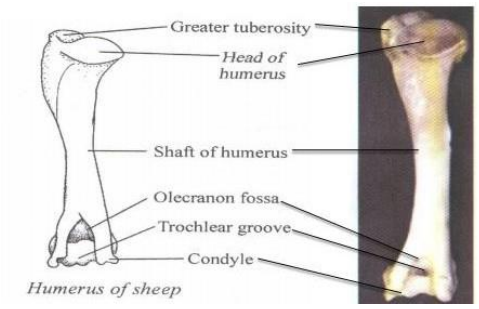
- ✓ Limbs of mammals/ vertebrates are pentadactyl limbs i.e. have five fingers/digits.

1. **Fore limbs**

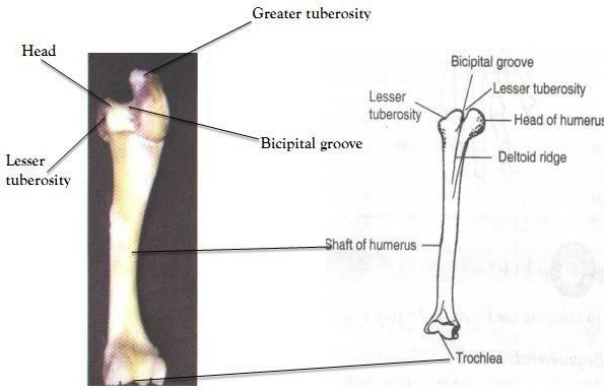
- ✓ They are two and each is made of the following bones:

i. Humerus.
ii. Ulna and radius.
iii. Carpals, metacarpals and phalanges.

i) **HUMERUS** -It is found on the upper arm (between the elbow and shoulder).



Humerus of sheep



Adaptations of humerus.

1. At the proximal end, it has **a large and broad rounded head** that articulates with the **glenoid cavity** of the scapula to form a ball and socket joint.
2. It has **long shaft** to increase the surface area for attachment of muscles.
3. The head of the humerus is covered with a cartilage to reduce friction during movement.
4. Near the head there is a rough surface called **tuberosity (greater and lower/lesser tuberosities)** to provide a surface for muscle attachment.
5. Between the **tuberosities** there is a groove called **bicipital groove** along which the tendon of the bicep muscle passes.
6. At the distal end are two rounded structure called **condyles** to articulate with the sigmoid notch of the radius and ulna to form a hinge joint (to allow movement of the arm in one plane).
7. Between the two condyles is a groove called **trochlea** for articulation with sigmoid notch radius and ulna to form hinge joint.

B. **ULNA AND RADIUS.**

- These are two curved long bones found on the lower arm (between the elbow and the wrist).
- The radius lies on the upper side/ side of the thumb and ulna on the lower side/ side of the small finger of the lower arm.

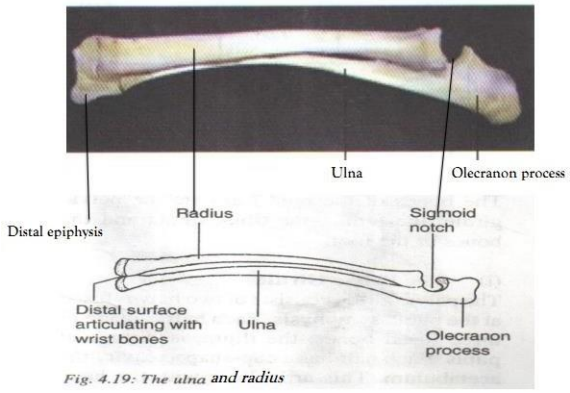
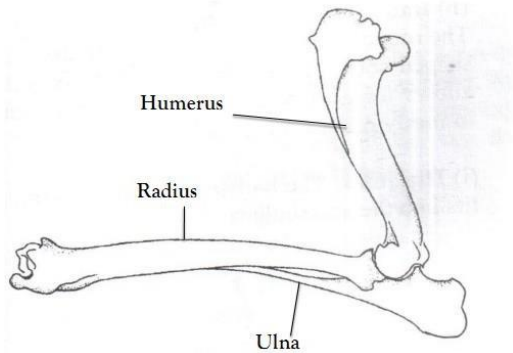


Fig. 4.19: The ulna and radius



Articulation of humerus with ulna and radius

Adaptations.

1. They have **a sigmoid notch (at the proximal end)** which articulates with (the trochlea and condyles of) the humerus to form hinge joint.
2. The ulna has (an extension beyond the sigmoid notch called) **olecranon process** which provides a large surface area for attachment of muscles and tendons and also prevents overstretching of the forearm at the joint when straightened.
3. At the distal end there is **distal epiphysis** for articulation with the **carpals** to form gliding joint.
4. They have long shaft to increase surface area for attachment of muscles.

C. **BONES OF THE HAND.**

- ✓ They include carpals, metacarpals and phalanges.
- ✓ They are small bones provide a site for muscle attachment.
- ✓ Carpals are found at the wrist and articulate with distal epiphysis of ulna-radius to form gliding joint.
- ✓ Metacarpals are found/ located at the palm and articulate with each other to form **gliding joints.**
- ✓ **Phalanges** are found at the fingers and articulate with each other to form **hinge joints.**

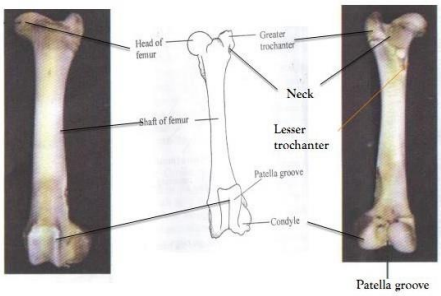
2. **HIND LIMBS.**

- There are two hind limbs and each consists of the following bones:

A. Femur.
B. Tibia and fibula.
C. Tarsals, metatarsals and phalanges.

A. **Femur.**

- This is a thigh bone found between the hip and the knee/ on the upper hind limb.



Adaptations of femur.

1. It has a **head** (at the proximal end) that articulates with **acetabulum** of the pelvic girdle to form ball and socket joint.
2. The head of the femur is covered with a cartilage that reduces friction during locomotion.
3. It has rounded **condyles** (at the distal end) which articulate with the patella/ knee cap and **tibia** to form hinge joint.
4. It has a long shaft to provide a large/ increase surface area for muscle attachment and for support.
5. The femur has projections called **greater and lesser trochanters to** provide a large surface area for muscle attachment.
6. Between the condyles there is a groove called **patella groove** which articulates with patella/ knee cap.

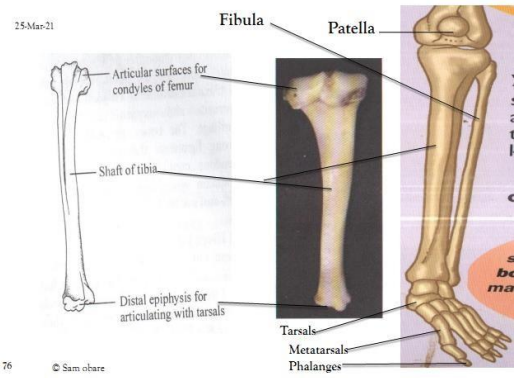
Functions of patella/ knee cap

1. Provides a site for muscle attachment.
2. Makes the knee joint flexible.
3. Prevents overstretching of hind limb at the knee joint.

B. **TIBIA AND FIBULA.**

✓ They are fused bones of the lower hind limb (between the ankle and knee). They form **shin bone.**

✓ The thicker and longer bone is called **tibia** and the shorter and thinner bone is **fibula.**



✓

Adaptations.

1. They have long shaft to increase surface area for attachment of muscles and tendons and for support.
2. Tibia has articular facets (at the proximal end) for articulation with condyles of femur to form hinge joint.
3. They have distal epiphysis which articulates with tarsals to form gliding joint.

C. **TARSALS, METATARSALS AND PHALANGES**

✓ **Tarsals** are found at the ankle and articulate with distal epiphysis of tibia to form **gliding joints.**

✓ **Metatarsals** are found at the sole and articulate with each other to form gliding joints.

✓ **Phalanges** are found at the fingers and articulate with each other to form **hinge joints.**

JOINTS.

✓ **A joint** is a connection between two bones.

✓ At the joint, a bone is connected to another bone by inelastic tissue called **ligament.**

✓ At the joint a muscle is connected to the bone by inelastic tissue called **tendon**

Types of joints.

A. **Fixed /immovable joints** e.g. fused bones of the skull and the pelvic girdle.

B. **Gliding joints** e.g. at the wrist (between ulna-radius and carpals) and ankle between tibia and tarsals), between the vertebrae in the vertebral column.

C. **Pivot joints** e.g. joint between the atlas and axis.

D. **Movable joints e.g.** ball and socket joint, hinge joint, joints between phalanges.

- Movable joints with a synovial fluid are called synovial joints e.g. ball and socket and hinge joints.

Functions of a joint.

1. Allows movement to occur between the bones.

2. Some joints allow passage of blood vessels and nerves.

SYNOVIAL JOINTS.

✓ They allow some considerable degree of movement.

✓ The head of the bones is covered by **articular cartilage and synovial fluid** that reduce friction during movement.

Components of a synovial joint.

1. **Bones-** provide a site for attachment of muscles.
2. **Ligament-** Attaches a bone to another bone.
3. **Cartilage-** acts as a shock absorber and reduces friction during movement.
4. **Synovial membrane-** secretes and encloses synovial fluid.
5. **Tendon-**connects a muscle to the bone.
6. **Synovial fluid-** Nourishes the tissue/supplies oxygen and nutrients, lubricates the joint, acts as a shock absorber, reduces friction and distributes pressure at the joint.

Types of synovial joints.

A. Hinge joint.

B. Ball and socket joint.

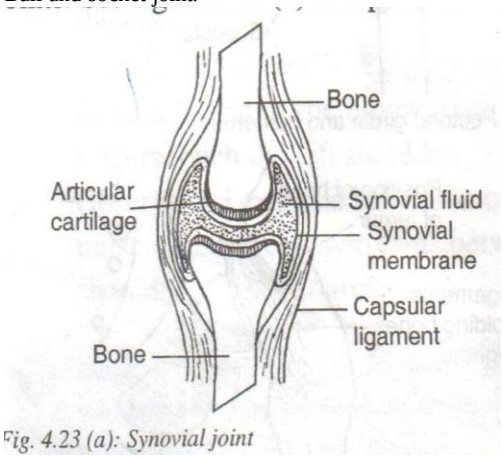


Fig. 4.23 (a): Synovial joint

A. **Hinge joint**

✓ In this type, one bone has a depression and the other has smooth condyles that fit and articulates in the depression.

✓ It allows movement in one direction/plane/through 180 degrees.

Examples of hinge joint.

i. **Elbow joint-** between the humerus and ulna & radius.

ii. **Knee joint-** between the femur and tibia.

iii. Joint between the phalanges.

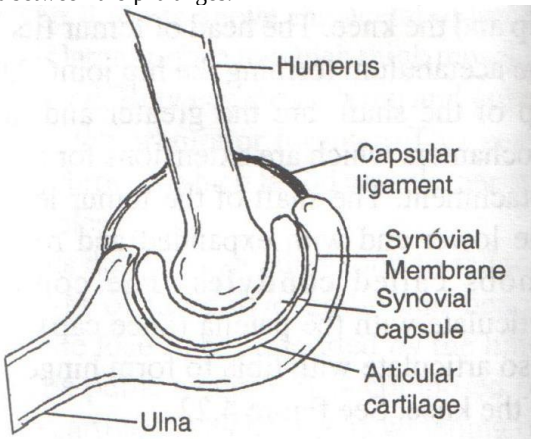
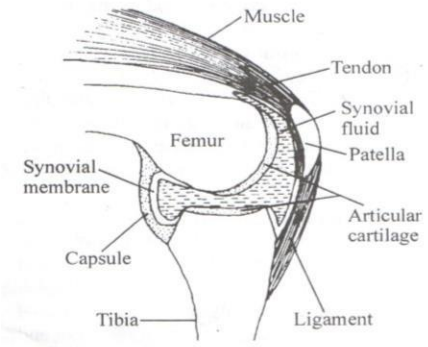


Fig. 4.25: Ulna-humerus hinge joint



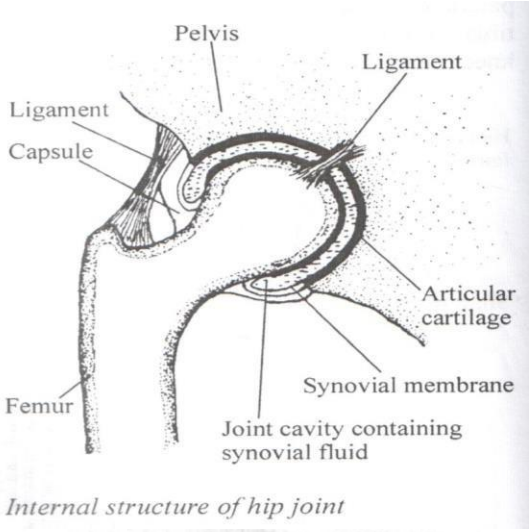
Internal structure of knee joint

B. **Ball and socket joint**

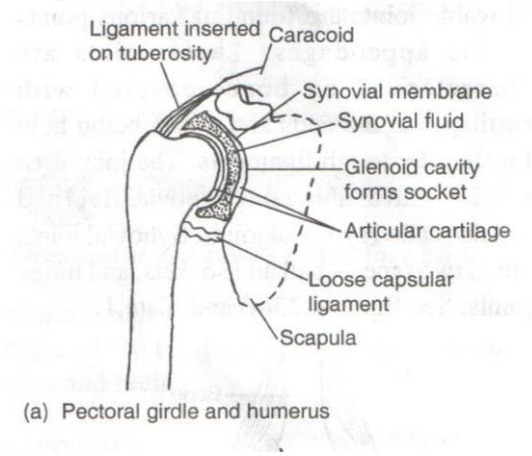
- ✓ In this type one has a rounded head and the other has a cavity/socket into which the head fits/articulates.
- ✓ It allows movement in all directions/planes/through 360 degrees.

Examples of ball and socket joints.

1. **Hip joint-** between the femur and pelvic girdle.
2. **Shoulder joint-** between the humerus and scapula.



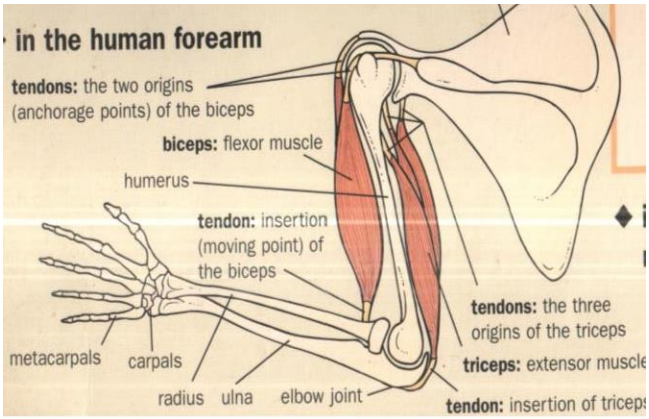
Internal structure of hip joint

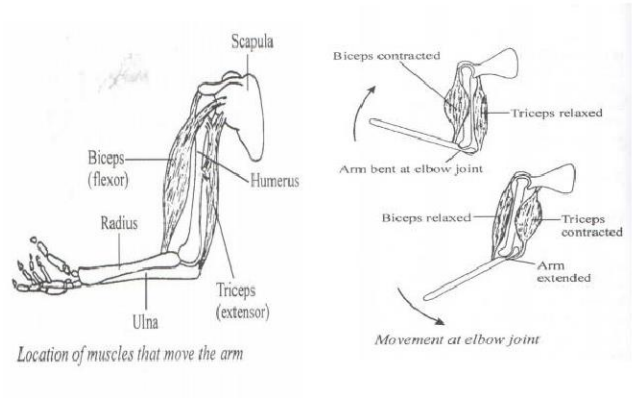


(a) Pectoral girdle and humerus

MOVEMENT AT THE JOINT.

- ✓ At a movable joint, the bones are held together by an inelastic tissue called **ligament.**
- ✓ The ligaments restrain movement of the bones thus preventing dislocation.
- ✓ At the joint, the muscles are held to the bones by inelastic tissue called **tendon.**
- ✓ Movement at the joint is brought about by muscles.
- ✓ The muscle that brings about bending/ flexing of the limb is called **flexor muscle / biceps** while the muscle that straightens the limb is called **extensor muscle /triceps.**
- ✓ Triceps and biceps are required when bending/ straightening the limb because they contract antagonistically i.e. when one relaxes the other contracts.
- ✓ When bending/ flexing the limb, the flexor muscle/ biceps contracts while the extensor muscle/ triceps relaxes.
- ✓ When straightening the limb, the biceps/ flexor muscle relaxes while the triceps/ extensor muscle contracts.





Study question.

Describe how nerve impulses to a muscle leads to bending of a limb.

- ✓ ***The impulse excites the flexor muscle making it to contract. The contraction creates a force which is transmitted onto the skeleton by tendons pulling the bones closer hence bending.***

MUSCLES.

- ✓ A muscle is a specialized tissue for contraction and relaxation to allow movement.
- ✓ The functional unit of a muscle is called **myofibril** which has the ability to contract.
- ✓ The myofibril consists of proteins called **myosin and actin** which facilitate contraction and relaxation**.**
- ✓ Contraction of muscles requires **sodium and calcium ions.**

Types of muscles.

A. Skeletal/ striated muscles.
B. Smooth/ unstriated/ visceral muscles.
C. Cardiac muscle.

A. **Skeletal muscles.**

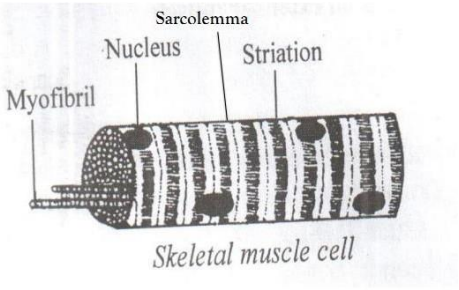
- ✓ They are located/attached to the bones/skeleton.
- ✓ They contract bringing about movement of limbs.

Characteristics of skeletal muscle.

1. Composed of long fibres and each fibre is composed of numerous myofibrils that have multiple nuclei (it is multinucleated).
2. It is cylindrical in shape.
3. The fibres are striated/ have striations.
4. Contraction is controlled by voluntary nervous system.
5. The muscle contracts faster and fatigue quickly/ easily.
6. The fibres contract antagonistically creating a force that is transmitted to the skeleton by tendon to bring about movement of limbs.

Adaptation of skeletal muscles

1. Skeletal muscles have actin and myosin/contractile proteins which facilitate contraction and relaxation.
2. Have numerous mitochondria provide energy for contraction.
3. Have elongated fibres to allow change in length.



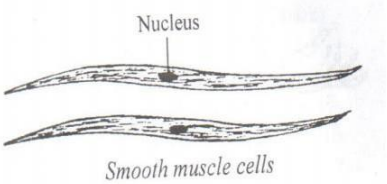
Skeletal muscle cell

B. **SMOOTH/ VISCERAL MUSCLES.**

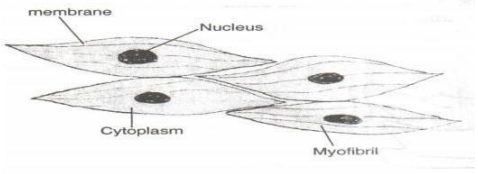
- ✓ They are found along the walls of tubular internal/ visceral organs e.g. trachea, ureter, urethra, blood vessels, alimentary canal/ gut, reproductive tract, blood vessels.
- ✓ They are also found in the ciliary body, iris of the eye and erector pili muscle.
- ✓ They bring about peristaltic movement of food materials, blood and body fluids.

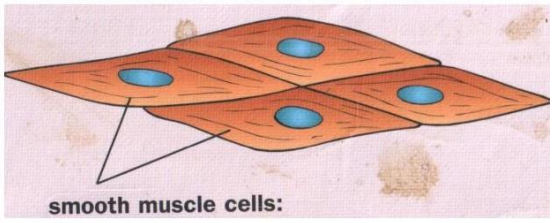
Characteristics of smooth muscles

1. They consist of short fibres.
2. Each fibre has one/ single nucleus (uninucleated)
3. They are not striated/are unstriated.
4. They are spindle shaped.
5. Contraction is controlled by involuntary nervous system.
6. They contract slowly and do not fatigue easily.



Smooth muscle cells





C. **CARDIAC MUSCLE**

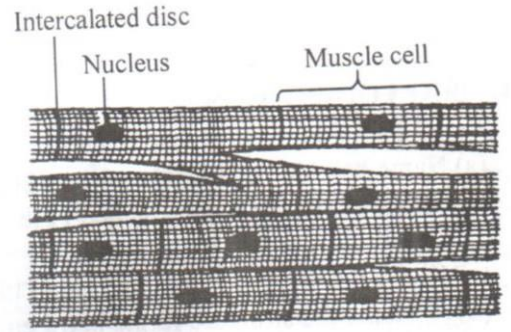
- ✓ This is a heart muscle / found on the heart.
- ✓ Its contraction and relaxation brings about the heartbeat.

Characteristics

1. It has branched fibres which are striated but with intercalated discs.
2. Each muscle fibre consists of short cells with a single/ one nucleus (uninucleated).
3. It contracts continuously without fatigue.
4. It is **myogenic** i.e. contraction originates from within itself without nervous/ hormonal stimulation.
5. Its contraction is controlled by autonomic/ involuntary nervous system.

Adaptations of cardiac muscle

1. Cells are joined by intercalated discs that transmit impulses rapidly throughout the heart.
2. It has more mitochondria (than skeletal muscles) to provide energy for contraction.



Cardiac muscle cells